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Publications of the Exobiology
Program for 1990

A Special Bibliography

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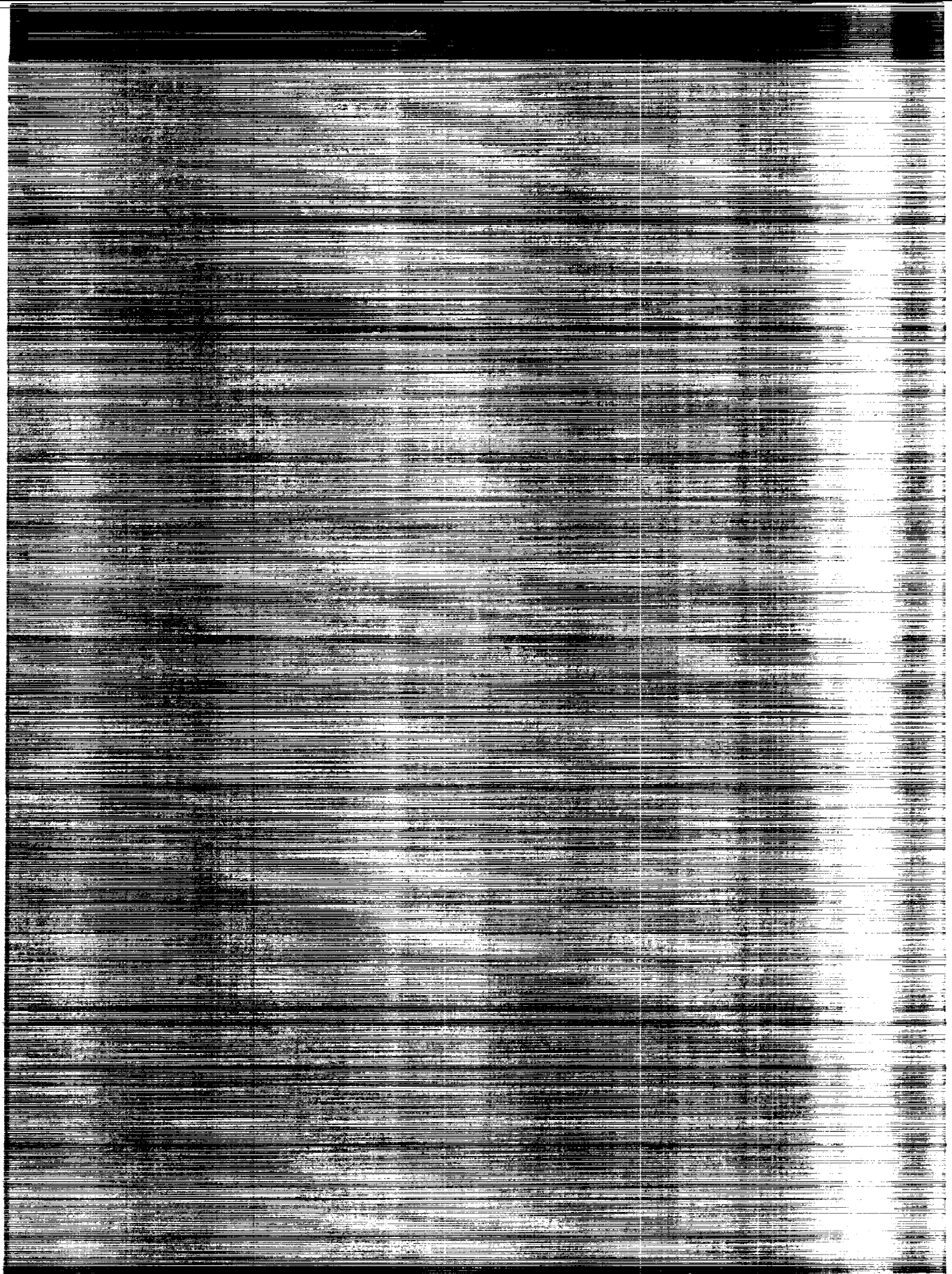
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Publications of the Exobiology Program for 1990

A Special Bibliography

*The George Washington University
Washington, D.C.*

and

*NASA Office of Space Science and Applications
Washington, D.C.*



National Aeronautics and
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Information Program

1992

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Introduction

The Exobiology Program, located within the Life Sciences Division, Office of Space Science and Applications of the National Aeronautics and Space Administration, is an integrated program designed to investigate and understand those processes related to the origin, evolution, and distribution of life in the universe.

This report contains a listing of 1990 publications resulting from research supported by the Exobiology Program. Our intent in compiling this bibliography is twofold: to provide the scientific community with an annual publication listing (as we have done since 1975) of current NASA-supported research in this field, and to stimulate the exchange of information and ideas among the scientists working in the different areas of the program.

The Exobiology Program is broad in scope, covering the following subject areas: **Cosmic Evolution of Biogenic Compounds, Prebiotic Evolution, Early Evolution of Life, Evolution of Advanced Life, Solar System Exploration, Search for Extraterrestrial Intelligence, Planetary Protection, and Advanced Programs in Biological Systems Research.**

Cosmic Evolution of Biogenic Compounds focuses on understanding the cosmic history of the biogenic elements (C, H, N, O, P, S) and their compounds in the galaxy and early solar system and understanding the mechanisms of their incorporation (evolution) into organic compounds. This includes: (1) tracing the physical and chemical pathways of the biogenic elements and their compounds from their origins in stars to their incorporation in pre-planetary bodies, (2) determining the kinds of measurements that can be made on the biogenic elements and their compounds to develop theories about solar system formation and prebiotic evolution, and the origin of life, and (3) determining the ways in which the physical and chemical properties of the biogenic elements and their compounds may have influenced the course of events during the formation of the solar system and component bodies.

Prebiotic Evolution seeks to understand how the evolutionary sequence leading from simple chemicals to living systems occurred during the development of the Earth and other planets. Research and analysis falls into two major areas: (1) the consequences of planetary evolution on the physical environment of the Earth and planets, including the importance of the physical-chemical processes associated with the development of dynamic planetary surfaces, and (2) the evolution of molecules and molecular systems focusing on energetics, dynamics, and synthesis of chemicals and chemical systems to determine mechanisms by which these systems acquired biological attributes under the constraints imposed by the physical environment.

Early Evolution of Life focuses on the nature and history of primitive organisms, relating their evolution to those forces that shaped the evolution of the Earth. The evolutionary record occurs in two forms: the familiar fossil record in rocks, in which phylogeny is deduced from morphology, and in the genome of extant organisms, where mutational events, the driving force of evolution, are expressed in sequences found in the organism's nucleic acids, or the gene products. Thus, studies use the geological record and the molecular record in living organisms to determine when and in what setting life first appeared, to determine the characteristics of the first successful living organisms, to understand the phylogeny and physiology of primitive organisms, to understand the evolution of energy-transducing systems, and to understand what determines the rate of mutation (evolution).

Evolution of Advanced Life examines the influence of astrophysical, stellar, and solar system impact events on the evolution of advanced life on Earth, with specific regard to their role in species extinctions. Research in this area focuses on understanding the role of extinction in evolution and the physical conditions that cause extinction of species.

Solar System Exploration focuses on providing specific information on the elemental and chemical composition, mainly with respect to the biogenic elements, of the atmospheres and surfaces of solar system bodies, including planets and their satellites, comets, asteroids, meteorites, and dust in space. Improved technology, instrumentation, and experiments are being developed for exploration of solar system bodies and interstellar space. Areas of recent emphasis have centered around developing methods to search for traces of extinct martian biota and developing model systems, such as Antarctica, as analogs for studying the possible evolution of life on Mars.

Search for Extraterrestrial Intelligence (SETI) involves the search for extraterrestrial intelligent life by detecting signals in the electromagnetic spectrum, particularly the microwave frequency range from 1 to 10 GHz. The principal component of this project is the Microwave Observing Project, which consists of two elements, a Targeted Search and a Sky Survey. Also included in SETI is the SERENDIP system and a high resolution Infrared Spectrometer.

Planetary Protection focuses on protection of the various bodies of the solar system from possible forward or backward biological materials contamination, based on explicit guidelines defined and being defined for each solar system body and each type of mission. With regard to the Space Exploration Initiative's focus of establishing a human presence on Mars, cross contamination of Earth and Mars has become an important issue.

Advanced Programs in Biological Systems Research is a new area, focusing on research and analysis tasks that are multidisciplinary, that establish interfaces among the Exobiology, Biospherics, and Controlled Ecological Life Support System (CELSS) Research Programs, and that begin laying the groundwork for advanced missions. This involves (1) determining the basis for the origin and development of ecological interactions between organisms and their environment in both natural and artificial ecosystems, (2) developing methods for characterizing the state and dynamical interactions of biological systems in and with their environment, and (3) assessing the requirements for the feasibility of creating habitable extraterrestrial environments, i.e., Mars, Space Station Freedom, Lunar Base.

This bibliography is divided into the areas noted above. Within each research area, publications are listed alphabetically by author. Authors who are Principal Investigators are identified by an asterisk. In addition, current addresses for all Principal Investigators are listed in the Appendix.

We wish to thank all the participants in the Exobiology Program for their cooperation in responding to our requests for listings of their 1990 publications. We also wish to thank Janice Wallace-Robinson and Janet Vaughn Powers for their editorial and technical assistance and Audrey Brown for her technical assistance in compiling this bibliography.

John D. Rummel, Ph.D.
Exobiology Program Manager
January 1992

Cosmic Evolution of Biogenic Compounds

Allamandola*, L.

The nature of interstellar/pre-cometary dust.

In: *Physics and Composition of Interstellar Matter* (Krelowski, J., Papaj, J., Eds.). Torun, Poland: Institute of Astronomy of the Nicolaus Copernicus University, p. 9-36, 1990. (GWU 14103)

Allamandola*, L.J.

Benzenoid hydrocarbons in space: The evidence and implications.

Topics in Current Chemistry (Advances in the Theory of Benzenoid Hydrocarbons) 153: 3-25, 1990. (GWU 14176)

Allamandola*, L.J.; Sandford, S.A.

Interstellar grain chemistry and organic molecules.

In: *Carbon in the Galaxy: Studies from Earth and Space* (Tarter, J.C., Chang, S., DeFrees, D.J., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 113-146, 1990. (NASA-CP-3061) (GWU 8846)

Anicich, V.G.; Sen, A.D.; Huntress, W.T., Jr.; McEwan, M.J. (Hanner, M.S. = P.I.)

Association reactions at low pressure. III. The $C_2H_2^+/C_2H_2$ system.

Journal of Chemical Physics 93(10): 7163-7172, 1990. (GWU 14177)

Blake*, D.F.

Scanning electron microscopy.

In: *Instrumental Surface Analysis of Geological Materials* (Perry, D.L., Ed.). New York: VCH Publishers, p. 11-43, 1990. (GWU 14083)

Blake*, D.F.; Allamandola*, L.J.; Palmer, G.

Direct determination of the morphology, structure and composition of planetary, cometary and interstellar ice analogs (Abstract).

Lunar and Planetary Science Conference XXI: 95-96, 1990. (GWU 13585)

Blake*, D.F.; Allamandola*, L.J.; Palmer, G.; Pohorille, A.

Analytical electron microscopy of extraterrestrial ice analogs.

In: *XII International Congress for Electron Microscopy*, Seattle, WA, August 1990, p. 594-595. (GWU 14094)

Brownlee, D.E.; Bunch*, T.E.; Grounds, D.; Grün, E.; Hörz, F.; Rummel*, J.; Quaide, W.L.; Walker, R.M.

Cosmic Dust Collection Facility: Scientific Objectives and Programmatic Relations (Hörz, F., Ed.). Houston, TX: NASA, Johnson Space Center, 29 p., 1990. (NASA TM-102160) (GWU 14178)

Bunch*, T.E.; Schultz, P.; Brownlee, D.; Podolak, M.; Reynolds, R.; Cassen, P.; Chang*, S. Hypervelocity impact penetration experiments: A guide to the origin of rims on chondrules (Abstract).

Lunar and Planetary Science Conference XXI: 143-144, 1990. (GWU 13586)

Cronin*, J.R.; Pizzarello, S.

Aliphatic hydrocarbons of the Murchison meteorite.

Geochimica et Cosmochimica Acta 54: 2859-2868, 1990. (GWU 12296)

- Cronin*, J.R.; Pizzarello, S.
Aliphatic hydrocarbons of the Murchison meteorite.
Geochimica et Cosmochimica Acta 54: 2859-2868, 1990. (GWU 12296)
- Cronin*, J.R.; Pizzarello, S.
Indigenous hydrocarbons of the Murchison meteorite (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 243. (GWU 14179)
- Fleming, R.H.; Meeker, G.P.; Radicati di Brozolo, F.; Blake*, D.F.; White, L.D.
Isotope ratio imaging of interplanetary dust particles (Abstract).
Lunar and Planetary Science Conference XXI: 369-370, 1990. (GWU 14084)
- Grün, E.; Fechtig, H.; Hanner*, M.S.; Kissel, J.; Lindblad, B.A.; Linkert, D.; Maas, D.; Morfill, G.E.; Zook, H.A.
First results from the Galileo dust detector (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 109. (GWU 14180)
- Hartmetz, C.P.; Gibson*, E.K., Jr.
Volatiles present in interplanetary dust particles and contaminants collected on the large area collectors (Abstract).
Lunar and Planetary Science Conference XXI: 459-460, 1990. (GWU 13587)
- Hartmetz, C.P.; Gibson*, E.K., Jr.; Blanford, G.E.
In situ extraction and analysis of volatiles and simple molecules in interplanetary dust particles, contaminants, and silica aerogel.
In: *Proceedings of the 20th Lunar and Planetary Science Conference* (Sharpton, V.L., Ryder, G., Eds). Houston, TX: Lunar and Planetary Institute, p. 343-355, 1990. (GWU 11478)
- Hartmetz, C.P.; Gibson*, E.K., Jr.; Lauer, H.V.
A study of aerogel's suitability as an IDP collection substrate: Potential solutions to volatile contamination problems (Abstract).
Lunar and Planetary Science Conference XXI: 463-464, 1990. (GWU 13588)
- Hawkins, J.M.; Lewis, T.A.; Loren, S.D.; Meyer, A.; Heath, J.R.; Shibato, Y.; Saykally, R.J. (Tarter, J.C. = P.I.)
Organic chemistry of C₆₀ (Buckminsterfullerene): Chromatography and osmylation.
Journal of Organic Chemistry 55: 6250-6252, 1990. (GWU 14181)
- Heath, J.R.; Saykally, R.J. (Tarter, J.C. = P.I.)
The C₉ cluster: Structure and infrared frequencies.
Journal of Chemical Physics 93(11): 8392-8394. (GWU 14182)
- Heath, J.R.; Sheeks, R.A.; Cooksy, A.L.; Saykally, R.J. (Tarter, J.C. = P.I.)
The C₇ cluster: Structure and infrared frequencies.
Science 249(4971): 895-897, 1990. (GWU 14183)
- Irvine*, W.M.; Friberg, P.; Kaifu, N.; Matthews, H.E.; Minh, Y.C.; Ohishi, M.; Ishikawa, S.
Detection of formic acid in the cold, dark cloud L 134N.
Astronomy and Astrophysics 229: L9-L12, 1990. (GWU 12278)

- Irvine*, W.M.; Madden, S.C.; Ziurys, L.M.; Friberg, P.; Hjalmarson, A.; Matthews, H.E.; Turner, B.E.
Observations of the CH_2CN $1_{01}-0_{00}$ and $4_{04}-3_{03}$ transitions.
In: *Submillimeter Astronomy* (Watt, G.D., Webster, A.S., Eds.). Dordrecht, Holland: Kluwer Academic Publishers, p. 115, 1990. (GWU 14037)
- Karlsson, H.R.; Socki, R.A.; Gibson*, E.K., Jr.; Balafas, J.S.
Stable isotopic compositions of carbonates in Antarctic ordinary chondrites: Indicators of terrestrial weathering? (Abstract)
Meteoritics 25: 375-376, 1990. (GWU 12299)
- Kinard, W.H.; Zolensky, M.E.; Horz, F.; Kessler, D.; Zook, H.; See, T.H.; Simon, C.G.; Walker, R.; Zinner, E.; Atkinson, D.R.; Allbrooks, M.K.; McDonnell, J.A.M.; Humes, D.; Brownlee, D.; Mandeville, J.-C.; Finckenor, M.M.; Chobotov, V.; Bunch*, T.; Mirtich, M.
Inspection of the Long Duration Exposure Facility and plans to characterize the dust environment in low-Earth orbit (Abstract).
Lunar and Planetary Science Conference XXI: 686-687, 1990. (GWU 14116)
- Lumme, K.; Peltoniemi, J.I.; Irvine*, W.M.
Diffuse reflection from a stochastically bounded, semi-infinite medium.
Transport Theory and Statistical Physics 19(3-5): 317-332, 1990. (GWU 12274)
- Lynch, D.K.; Russell, R.W.; Hanner*, M.S.; Lien, D.J.
Comparison of p/Brorsen-Metcalf and p/Halley in the thermal infrared.
In: *Workshop on Observations of Recent Comets (1990)* (Huebner, W.F., Wehinger, P.A., Rahe, J., Konno, I., Eds.). San Antonio, TX: Southwest Research Institute, p. 70-74, 1990. (GWU 14242)
- Marquez, C.; Hartmetz, C.P.; Gibson*, E.K., Jr.; Oro*, J.
Volatile molecules produced from carbides of iron, calcium, and manganese by laser pulse (Abstract).
Lunar and Planetary Science Conference XXI: 734-735, 1990. (GWU 13592)
- McGonagle, D.; Ziurys, L.M.; Irvine*, W.M.; Minh, Y.C.
Detection of nitric oxide in the dark cloud L134N.
Astrophysical Journal 359(1, Pt. 1): 121-124, 1990. (GWU 12284)
- Minh, Y.C.; Ziurys, L.M.; Irvine*, W.M.; McGonagle, D.
Observations of H_2S toward OMC-1.
Astrophysical Journal 360: 136-141, 1990. (GWU 12283)
- Pendleton, Y.J.; Tielens, A.G.G.M.; Werner, M.W. (Allamandola, L.J. = P.I.)
Studies of dust grain properties in infrared reflection nebulae.
Astrophysical Journal 349: 107-119, 1990. (GWU 12662)
- Prialnik, D.; Bar-Nun, A. (Owen, T. = P.I.)
Gas release in comet nuclei.
Astrophysical Journal 363: 274-282, 1990. (GWU 13833)
- Prialnik, D.; Bar-Nun, A. (Owen, T. = P.I.)
Heating and melting of small icy satellites by the decay of ^{26}Al .
Astrophysical Journal 355: 281-286, 1990. (GWU 13834)

Salama, F.; Allamandola*, L.J.; Witteborn, F.C.; Cruikshank, D.P.; Sandford, S.A.; Bregman, J.D.

The 2.5-5.0 μm spectra of Io: Evidence for H_2S and H_2O frozen in SO_2 .

Icarus 83: 66-82, 1990. (GWU 11593)

Salama, F.; Allamandola*, L.J.; Witteborn, F.C.; Cruikshank, D.P.; Sandford, S.A.; Bregman, J.D.

The 2.5-5.0 μm spectra of Io: Evidence for H_2S and H_2O frozen in SO_2 .

In: *Proceedings of the 24th ESLAB Symposium on the Formation of Stars and Planets, and the Evolution of the Solar System*, Friedrichshafen, Germany, September 17-19, 1990. Noordwijk, The Netherlands: European Space Agency, p. 203-208, 1990. (ESA SP-315) (GWU 12593)

Sandford, S.A.; Allamandola*, L.J.

The physical and infrared spectral properties of CO_2 in astrophysical ice analogs.

Astrophysical Journal 355: 357-372, 1990. (GWU 12594)

Sandford, S.A.; Allamandola*, L.J.

The volume- and surface-binding energies of ice systems containing CO , CO_2 , and H_2O .

Icarus 87: 188-192, 1990. (GWU 12582)

Schmuttenmaer, C.A.; Cohen, R.C.; Pugliano, N.; Heath, J.R.; Cooksy, A.L.; Busarow, K.L.; Saykally, R.J. (Tarter, J.C. = P.I.)

Tunable far-IR laser spectroscopy of jet-cooled carbon clusters: The ν_2 bending vibration of C_3 .

Science 249(4971): 897-900, 1990. (GWU 14184)

Schutte, W.A.; Deamer*, D.; Allamandola*, L.J.; Sandford, S.A.

Laboratory simulation of the photoprocessing and warm-up of cometary and pre-cometary ices:

Production and analysis of complex organic molecules (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 243. (GWU 14185)

Schutte, W.A.; Tielens, A.G.G.M.; Allamandola*, L.J.; Cohen, M.; Wooden, D.H.

The anomalous 3.43 and 3.53 micron emission features toward HD 97048 and Elias 1: C-C vibrational modes of polycyclic aromatic hydrocarbons?

Astrophysical Journal 360: 577-589, 1990. (GWU 13420)

Socki, R.A.; Karlsson, H.R.; Gibson*, E.K.

A rapid, inexpensive technique for analysis of $^{18}\text{O}/^{16}\text{O}$ in water using pre-evacuated containers (Abstract).

In: *Seventh International Conference on Geochronology, Cosmochronology, and Isotope Geology*, 1990, p. 94. (GWU 12300)

Tarter*, J.C.; Chang*, S.; DeFrees*, D.J. (Eds.)

Carbon in the Galaxy: Studies from Earth and Space.

Moffett Field, CA: NASA, Ames Research Center, 360 p., 1990. (NASA-CP-3061)

(GWU 12629)

Tielens, A.G.G.M. (Allamandola, L.J. = P.I.)

Carbon stardust: From soot to diamonds.

In: *Carbon in the Galaxy: Studies from Earth and Space* (Tarter, J.C., Chang, S., DeFrees, D.J., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 59-111, 1990. (NASA-CP-3061) (GWU 8845)

Tielens, A.G.G.M. (Allamandola, L.J. = P.I.)

Towards a circumstellar silicate mineralogy.

In: *From Miras to PN: Which Path for Stellar Evolution?* (Mennessier, M.-O., Ed.). Editions Frontieres, 15 p., 1990. (GWU 12663)

Turner, B.E.; Friberg, P.; Irvine*, W.M.; Saito, S.; Yamamoto, S.

Interstellar cyanomethane.

Astrophysical Journal 355: 546-561, 1990. (GWU 12280)

Ziurys, L.M. (Irvine, W.M. = P.I.)

Millimeter and submillimeter studies of interstellar high temperature chemistry.

In: *Submillimeter Astronomy* (Watt, G.D., Webster, A.S., Eds.). Dordrecht, Holland: Kluwer Academic Publishers, p. 109, 1990. (GWU 14036)

Prebiotic Evolution

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Aymami, J.; Coll, M.; van der Marel, G.A.; van Boom, J.H.; Wang, A.H.-J.; Rich*, A.
Molecular structure of nicked DNA: A substrate for DNA repair enzymes.
Proceedings of the National Academy of Sciences, USA 87: 2526-2530, 1990. (GWU 13013)

Baeza, I.; Ibáñez, M.; Santiago, J.C.; Argüello, C.; Wong, C.; Oró*, J.
Diffusion of Mn^{2+} ions into liposomes mediated by phosphatidate and monitored by the activation of an encapsulated enzymatic system.
Journal of Molecular Evolution 31(6): 453-461, 1990. (GWU 14186)

Cabrera, A.L.; Maple, M.B.; Arrhenius*, G.
Catalysis of carbon monoxide methanation by deep sea manganate minerals.
Applied Catalysis 64: 309-320, 1990. (GWU 8242)

Castillo-Rojas, S.; Navarro-González, R.; Negrón-Mendoza, A. (Ponnamperuma, C. = P.I.)
Experimental study and kinetic modeling of the gamma radiolysis of aqueous solutions of malic acid (Abstract).
In: *Abstracts of Papers for the Thirty-Eighth Annual Meeting of the Radiation Research Society*, New Orleans, LA, April 7-12, 1990, p. 142. (GWU 13850)

Cheikh, A.B.; Orgel*, L.E.
Polymerization of amino acids containing nucleotide bases.
Journal of Molecular Evolution 30: 315-321, 1990. (GWU 12109)

Chyba, C. (Sagan, C. = P.I.)
Seeding Earth: Comets, oceans and life.
Planetary Report X(1): 20-23, 30, 1990. (GWU 12312)

Chyba, C.; Sagan*, C.
Cometary and asteroidal delivery of prebiotic organics vs. *in situ* production on the early Earth (Abstract).
Bulletin of the American Astronomical Society 22(3): 1097, 1990. (GWU 14187)

Chyba, C.F.; Thomas, P.J.; Brookshaw, L.; Sagan*, C.
Cometary delivery of organic molecules to the early Earth.
Science 249: 366-373, 1990. (GWU 12414)

Danielson, A.; Möller, P. (Holland, H.D. = P.I.)
Is the Europium-anomaly in BIF a result of extensive hydrothermal alteration of Archean seafloor? A theoretical explanation (Abstract).
In: *Third International Archaeon Symposium, Extended Abstracts* (Glover, J.E., Ho, S.E., Compilers). Perth, Scotland: Geoconferences, Inc., p. 329-330, 1990. (GWU 13841)

Deamer*, D.W.
Origins of amphiphilic molecules and their role in prebiotic evolution (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 246. (GWU 14188)

Deamer*, D.W.; Harang, E.
Light-dependent pH gradients are generated in liposomes containing ferrocyanide.
BioSystems 24: 1-4, 1990. (GWU 12415)

Dirr, H.V.; Danielson, A.; Beukes, N.J. (Holland, H.D. = P.I.)
Oxygen isotopes in the carbonates of the Campellrand Subgroup, Northern Cape, South Africa (Abstract).

In: *Third International Archaeal Symposium, Extended Abstracts* (Glover, J.E., Ho, S.E., Compilers). Perth, Scotland: Geoconferences, Inc., p. 311, 1990. (GWU 13842)

Doudna, J.A.; Szostak, J.W.; Rich*, A.; Usman, N.
Chemical synthesis of oligoribonucleotides containing 2-aminopurine: Substrates for the investigation of ribozyme function.

Journal of Organic Chemistry 55: 5547-5549, 1990. (GWU 13540)

Drenkard, S.; Ferris*, J.; Eschenmoser, A.

Chemistry of α -aminonitriles. Aziridine-2-carbonitrile: Photochemical formation from 2-aminopropenenitrile. (German)

Helvetica Chimica Acta 73: 1373-1390, 1990. (GWU 12305)

Egli, M.; Gessner, R.V.; Williams, L.D.; Quigley, G.J.; van der Marel, G.A.; van Boom, J.H.; Rich*, A.; Frederick, C.A.

Atomic-resolution structure of the cellulose synthase regulator cyclic diguanylic acid.

Proceedings of the National Academy of Sciences, USA 87: 3235-3239, 1990. (GWU 13016)

Ertem, G.; Ferris*, J.P.

RNA oligomer formation on montmorillonite: The prebiotic formation of the phosphodiester bond (Abstract).

In: *27th Annual Meeting, Clay Minerals Society*, Columbia, MO, October 6-11, 1990, p. 48. (GWU 12304)

Ferris*, J.P.; Guillemin, J.C.

Photochemical cycloaddition reactions of cyanoacetylene and dicyanoacetylene.

Journal of Organic Chemistry 55(21): 5601-5606, 1990. (GWU 12293)

Ferris*, J.P.; Kamaluddin; Ertem, G.

Oligomerization reactions of deoxyribonucleotides on montmorillonite clay: The effect of mononucleotide structure, phosphate activation and montmorillonite composition on phosphodiester bond formation.

Origins of Life and Evolution of the Biosphere 20: 279-291, 1990. (GWU 12275)

Fishel, R.; Anziano, P.; Rich*, A.

Z-DNA affinity chromatography.

Methods in Enzymology 184: 328-340, 1990. (GWU 13450)

Fox*, S.W.

Artificial bio-intelligence (Abstract).

In: *5th International Symposium on Biological and Artificial Intelligence Systems*, Rome, Italy, September 3-6, 1990, p. 21. (GWU 12302)

Fox*, S.W.

The emergence of living functions from molecules.

In: *Symmetries in Science IV: Biological and Biophysical Systems* (Gruber, B., Yopp, J.H., Eds.). New York: Plenum Press, p. 53-66, 1990. (GWU 12301)

Fox*, S.W.
Oparin, the first cells, and selection processes.
In: *Prebiological Self Organization of Matter* (Ponnamperuma, C., Eirich, F.R., Eds.). Hampton, VA: A. Deepak Publishing, p. 183-195, 1990. (GWU 12285)

Fox*, S.W.
Thermal proteins in the first life and in the "mind-body" problem (Abstract).
In: *Evolution of Information Processing*, International Meeting under Bertelsmann Foundation, Universität Bremen, Bremen, Germany, October 8-10, 1990.

Frederick, C.A.; Williams, L.D.; Ughetto, G.; van der Marel, G.A.; van Boom, J.H.; Rich*, A.; Wang, A.H.-J.
Structural comparison of anticancer drug-DNA complexes: Adriamycin and daunomycin.
Biochemistry 29: 2538-2549, 1990. (GWU 13011)

Greenberg, J.M. (Ferris, J.P. = P.I.)
What have we learned; Where do we go from here?
In: *Carbon in the Galaxy: Studies from Earth and Space* (Tarter, J.C., Chang, S., DeFrees, D.J., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 311-316, 1990. (NASA-CP-3061) (GWU 11423)

Harada, K.; Orgel*, L.E.
Synthesis of 5'-deoxy-5'-nucleosideacetic acid derivatives.
Nucleosides & Nucleotides 9(6): 771-785, 1990. (GWU 12419)

Harada, K.; Orgel*, L.E.
Template-directed oligomerization of 5'-deoxy-5'-nucleosideacetic acid derivatives.
Origins of Life and Evolution of the Biosphere 20: 151-160, 1990. (GWU 12418)

Harang, E.A.; Deamer*, D.W.
Amino acid permeability across liposome bilayers (Abstract).
Biophysical Journal 57: 487a, 1990. (GWU 13941)

Holland*, H.D.; Beukes, N.J.
A paleoweathering profile from Griqualand West, South Africa: Evidence for a dramatic rise in atmospheric oxygen between 2.2 and 1.9 bybp.
American Journal of Science 290-A: 1-34, 1990. (GWU 12606)

Honda, Y.; Navarro-Gonzalez, R.; Ponnamperuma*, C.
The electrolysis of a simulated primitive atmosphere: CH₄-N₂-H₂O. I. Development of dosimetric methods (Abstract).
In: *Abstracts of Papers for the Thirty-Eighth Annual Meeting of the Radiation Research Society*, New Orleans, LA, April 7-12, 1990, p. 142. (GWU 13851)

Kanavarioti*, A.; Bernasconi, C.F.
Computer simulation in template-directed oligonucleotide synthesis.
Journal of Molecular Evolution 31: 470-477, 1990. (GWU 12422)

Kanavarioti*, A.; Chang*, S.; Alberas, D.J.
Limiting concentrations of activated mononucleotides necessary for poly(C)-directed elongation of oligoguanylates.
Journal of Molecular Evolution 31: 462-469, 1990. (GWU 12416)

Kanavarioti*, A.; Mancinelli*, R.L.

Could organic matter have been preserved on Mars for 3.5 billion years?

Icarus 84(1): 196-202, 1990. (GWU 12417)

Kerridge*, J.F.

Carbon in primitive meteorites.

In: *Carbon in the Galaxy: Studies from Earth and Space* (Tarter, J.C., Chang, S., DeFrees, D.J., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 3-20, 1990. (NASA-CP-3061) (GWU 11642)

Kerridge*, J.F.; Eugster, O.; Kim, J.S.; Marti, K.

Lunar and solar nitrogen from 3.7 Gyr ago (Abstract).

Lunar and Planetary Science Conference XXI: 623-624, 1990. (GWU 13590)

Khare*, B.N.; Thompson, W.R.; Cheng, L.; Arakawa, E.T.; McDonald, G.D.; Sagan*, C.
Spectral and compositional properties of cometary dust analogues: Residues from C₂H₆-H₂O ice irradiation (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 243. (GWU 14189)

Khare*, B.N.; Thompson, W.R.; Sagan*, C.; Arakawa, E.T.; Bruel, C.; Judish, J.P.; Khanna, R.K.; Pollack*, J.B.

Optical constants of solid methane (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 244. (GWU 14190)

Khare*, B.N.; Thompson, W.R.; Sagan*, C.; Arakawa, E.T.; Meisse, C.; Gilmour, I.

Optical constants of kerogen from 0.15 to 40 μm: Comparison with meteoritic organics.

In: *First International Conference on Laboratory Research for Planetary Atmospheres* (Fox, K., Allen, J.E., Jr., Stief, L.J., Quillen, D.T., Eds.). Washington, DC: NASA, Headquarters, p. 340-356, 1990. (NASA-CP-3077) (GWU 11712)

Khare*, B.N.; Thompson, W.R.; Sagan*, C.; Arakawa, E.T.; Meisse, C.; Gilmour, I.

Optical constants of kerogen from 0.15 to 40 μm: Comparison with meteoritic organics (Abstract).

Lunar and Planetary Science Conference XXI: 627-628, 1990. (GWU 13591)

Khare*, B.N.; Thompson, W.R.; Sagan*, C.; Arakawa, E.T.; Miesse, C.; Gilmour, I.

Optical constants of Murchison organic residue and kerogens (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 111. (GWU 14191)

Lacey*, J.C., Jr.

Hydrophobicity as an organizing principle in the origin of the genetic code.

In: *Prebiological Self Organization of Matter* (Ponnamperuma, C., Eirich, F.R., Eds.). Hampton, VA: A. Deepak Publishing, p. 117-130, 1990. (GWU 12264)

Lacey*, J.C., Jr.; Staves, M.P.

Was there a universal tRNA before specialized tRNAs came into existence?

Origins of Life and Evolution of the Biosphere 20: 303-308, 1990. (GWU 12267)

Lacey*, J.C., Jr.; Staves, M.P.; Thomas, R.D.
Ribonucleic acids may be catalysts for the preferential synthesis of L-amino acid peptides:
A minireview.
Journal of Molecular Evolution 31: 244-248, 1990. (GWU 12268)

Lacey*, J.C., Jr.; Thomas, R.D.; Wickaramasinghe, N.S.M.D.; Watkins, C.L.
Chemical esterification of 5'-AMP occurs predominantly at the 2' position.
Journal of Molecular Evolution 31: 251-256, 1990. (GWU 12266)

Lazcano, A.; Oró*, J.
The origin of early evolution of nucleic acid polymerases (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague,
The Netherlands, June 25-July 6, 1990, p. 247. (GWU 14192)

Lazcano, A.; Valverde, V.; Fastag, J.; Gariglio, P.; Ramirez, C.; Oro*, J.
Molecular evolution of nucleic acid polymerases.
In: *Prebiological Self Organization of Matter* (Ponnamperuma, C., Eirich, F.R., Eds.). Hampton,
VA: A. Deepak Publishing, p. 219-233, 1990. (GWU 11537)

Levine*, J.S.
The atmosphere's evolution.
In: *Magill's Survey of Science: Earth Science Series* (Magill, F.N., Ed.). Englewood Cliffs, NJ:
Salem Press, p. 114-120, 1990. (GWU 13423)

Levine*, J.S.
The greenhouse effect.
In: *Magill's Survey of Science: Earth Science Series* (Magill, F.N., Ed.). Englewood Cliffs, NJ:
Salem Press, p. 1004-1011, 1990. (GWU 13422)

Levine*, J.S.
The history and evolution of the Earth's atmosphere.
In: *Global and Regional Environmental Atmospheric Chemistry*, Proceedings of the International
Conference on Global and Regional Environmental Atmospheric Chemistry, Beijing, China, May
3-10, 1989, p. 96-105, 1990. (GWU 13555)

Llaca, V.; Silva, E.; Lazcano, A.; Rangel, L.M.; Gariglio, P.; Oro*, J.
In search of the ancestral RNA polymerase: An experimental approach.
In: *Prebiological Self Organization of Matter* (Ponnamperuma, C., Eirich, F.R., Eds.). Hampton,
VA: A. Deepak Publishing, p. 247-260, 1990. (GWU 11539)

McCarthy, J.G.; Williams, L.D.; Rich*, A.
Chemical reactivity of potassium permanganate and diethyl pyrocarbonate with B DNA: Specific
reactivity with short A-tracts.
Biochemistry 29: 6071-6081, 1990. (GWU 13010)

McDonald, G.D.; Thompson, W.R.; Khare*, B.N.; Sagan*, C.
Analysis of solid residue from spark discharges in simulated Jovian atmospheres (Abstract).
Bulletin of the American Astronomical Society 22(3): 1036-1037, 1990. (GWU 14193)

Melosh*, H.J.

Atmospheric impact processes (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 112. (GWU 14194)

Melosh*, H.J.

Vapor plumes: A neglected aspect of impact cratering (Abstract).

Meteoritics 25(4): 386, 1990.

Melosh*, H.J.; Schneider, N.M.; Zahnle*, K.J.; Latham, D.

Ignition of global wildfires at the Cretaceous/Tertiary boundary.

Nature 343(6255): 251-254, 1990. (GWU 6018)

Mendis, D.A.; Arrhenius*, G.

Electrodynamic control in planetesimal accretion.

In: *Mantle to Meteorites* (Gopalan, K., Gaur, V.K., Somayajulu, B.L.K., Macdougall, J.D., Eds.). Bangalore, India: Indian Academy of Sciences, p. 29-33, 1990. (GWU 3609)

Navarro-González, R.; Honda, Y.; Ponnampuruma*, C.

The electrolysis of a simulated primitive atmosphere: $\text{CH}_4\text{-N}_2\text{-H}_2\text{O}$. II. An investigation of the initial products (Abstract).

In: *Abstracts of Papers for the Thirty-Eighth Annual Meeting of the Radiation Research Society*, New Orleans, LA, April 7-12, 1990, p. 142. (GWU 13849)

Navarro-González, R.; Negrón-Mendoza, A.; Ramos, S.; Ponnampuruma*, C.

Radiolysis of aqueous solutions of acetic acid in the presence of Na-montmorillonite.

Sciences Géologiques 85: 55-65, 1990. (GWU 13838)

Oberbeck*, V.R.; Fogleman*, G.

Impact constraints on the environment for chemical evolution and the continuity of life.

Origins of Life and Evolution of the Biosphere 20: 181-195, 1990. (GWU 14086)

Oberbeck*, V.R.; Fogleman*, G.

On the possibility of life on early Mars.

In: *Proceedings of the 20th Lunar and Planetary Science Conference* (Sharpton, V.L., Ryder, G., Eds.). Houston, TX: Lunar and Planetary Institute, p. 473-478, 1990. (GWU 14243)

Oro*, J.; Lazcano, A.

The cometary contribution to prebiotic chemistry (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 243. (GWU 14195)

Oro*, J.; Lazcano, A.

A holistic precellular organization model.

In: *Prebiological Self Organization of Matter* (Ponnampuruma, C., Eirich, F.R., Eds.). Hampton, VA: A. Deepak Publishing, p. 11-34, 1990. (GWU 11538)

Oró*, J.; Miller*, S.L.; Lazcano, A.

The origin and early evolution of life on Earth.

Annual Review of Earth and Planetary Sciences 18: 317-356, 1990. (GWU 11540)

Pappelis, A.J.; Bozzola, J.J.; Veremis, Y.J.; Kupferer, V.; Rowell, J.K.; Tindall, D.R.; Yopp, J.H.; Fox*, S.W.
Protocellular engineering: Network structure for protoneuronal studies (Abstract).
In: *First SIUC Workshop on Neuroengineering*, September 6-7, 1990.

Pohorille, A.; Pratt, L.R. (MacElroy, R.D. = P.I.)
Cavities in molecular liquids and the theory of hydrophobic solubilities.
Journal of the American Chemical Society 112: 5066-5074, 1990. (GWU 12420)

Pohorille, A.; Ross, W.S.; Tinoco, I., Jr. (MacElroy, R.D. = P.I.)
DNA dynamics in aqueous solution: Opening the double helix.
International Journal of Supercomputer Applications 4(3): 81-96, 1990. (GWU 14087)

Ponnamperuma*, C.; Eirich, F.R. (Eds.)
Prebiological Self Organization of Matter. Hampton, VA: A. Deepak Publishing, 1990.
(GWU 13848)

Ponnamperuma*, C.; Honda, Y.; Navarro-González, R.
Asymmetry and the origin of life.
In: *Symmetries in Science IV* (Gruber, B., Yopp, J.H., Eds.). New York: Plenum Press,
p. 193-203, 1990. (GWU 13837)

Powers, J.V.; Ponnamperuma*, C.
Chemical evolution and the origin of life: Bibliography supplement 1986.
Origins of Life and Evolution of the Biosphere 20: 55-86, 1990. (GWU 13835)

Raghunathan, G.; Kieber-Emmons, T.; Rein*, R.; Alderfer, J.L.
Conformational features of DNA containing a *cis-syn* photodimer.
Journal of Biomolecular Structure and Dynamics 7(4): 899-913, 1990. (GWU 12610)

Roy, A.C.; Powers, J.V. (Rummel, J.D. = P.I.)
Chemical evolution and the origin of life: Cumulative keyword subject index 1970-1986.
Origins of Life and Evolution of the Biosphere 20: 425-456, 1990. (GWU 12408)

Sagan*, C.
Exploring other worlds and protecting this one: The connection.
Planetary Report X(1): 4-7, 1990. (GWU 12311)

Sagan*, C.; Thompson, W.R.; Henry, T.J.; Schwartz, J.M.; Khare*, B.N.
Quantitative laboratory simulation of Titan's atmospheric chemistry (Abstract).
Bulletin of the American Astronautical Society 22(3): 1085, 1990. (GWU 14196)

Scattergood*, T.W.; Stone, B.; Lau, E.Y.; Oberbeck*, V.R.; Snetsinger, K.; Verma, S.
Photochemistry in Titan's stratosphere: Laboratory studies of the formation of aerosols and gases by UV photolysis (Abstract).
Bulletin of the American Astronautical Society 22(3): 1085-1086, 1990. (GWU 14197)

Senaratne, N.; Hobish, M.K.; Ponnamperuma*, C.
Direct interactions between amino acids and nucleotides as a possible explanation for the origin of the genetic code (Abstract).
In: *Prebiological Self Organization of Matter* (Ponnamperuma, C., Eirich, F.R., Eds.). Hampton, VA: A. Deepak Publishing, p. 148, 1990. (GWU 13847)

- Shemansky, D.E.; Yung*, Y.
Implications of the precipitation of nitrogen ions into the Saturn homopause (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 120. (GWU 12615)
- Shen, C.; Lazcano, A.; Oró*, J.
The enhancement activities of histidyl-histidine in some prebiotic reactions.
Journal of Molecular Evolution 31(6): 445-452, 1990. (GWU 14198)
- Shen, C.; Mills, T.; Oró*, J.
Prebiotic synthesis of histidyl-histidine.
Journal of Molecular Evolution 31: 175-179, 1990. (GWU 14027)
- Shen, C.; Yang, L.; Miller*, S.L.; Oró*, J.
Prebiotic synthesis of histidine.
Journal of Molecular Evolution 31: 167-174, 1990. (GWU 12172)
- Shia, R.-L.; Ha, Y.L.; Wen, J.-S.; Yung*, Y.L.
Two-dimensional atmospheric transport and chemistry model: Numerical experiments with a new advection algorithm.
Journal of Geophysical Research 95(D6): 7467-7483, 1990. (GWU 14023)
- Shibata, M.; Zielinski, T.J.; Rein*, R.
Molecular mechanism of base substitutional mutations: From hydrogen bonding to molecular dynamics.
In: *Theoretical Biochemistry and Molecular Biophysics* (Beveridge, D.L., Lavery, R., Eds.). Guilderland, NY: Adenine Press, p. 309-319, 1990. (GWU 12611)
- Stoker, C.R.; Boston, P.J.; Mancinelli*, R.L.; Segal, W.; Khare*, B.N.; Sagan*, C.
Microbial metabolism of tholin.
Icarus 85: 241-256, 1990. (GWU 14091)
- Thomas, P.J.; Brookshaw, L.; Chyba, C.F.; Sagan*, C.
Cometary and asteroid impacts and the introduction of organic molecules to the early Earth (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 112. (GWU 14199)
- Thomas, P.J.; Brookshaw, L.; Chyba, C.F.; Sagan*, C.
Numerical models of comet and asteroid impact on the early Earth: Implications for the delivery of organic molecules (Abstract).
EOS. Transactions, American Geophysical Union 71(43): 1429, 1990. (GWU 13321)
- Tohidi, M.; Orgel*, L.E.
Polymerization of the cyclic pyrophosphates of nucleosides and their analogues.
Journal of Molecular Evolution 30: 97-103, 1990. (GWU 11534)
- Tonks, W.B.; Melosh*, H.J.; McKinnon, W.B.
The fate of ejected Mercury mantle material from a giant impact (Abstract).
Lunar and Planetary Science Conference XXI: 1260-1261, 1990. (GWU 13593)

Turco, R.P.; Toon, O.B.; Ackerman, T.P.; Pollack*, J.B.; Sagan*, C.
Climate and smoke: An appraisal of nuclear winter.
Science 247: 166-176, 1990. (GWU 11740)

Tyagi, S.; Ponnampertuma*, C.
Nonrandomness in prebiotic peptide synthesis.
Journal of Molecular Evolution 30: 391-399, 1990. (GWU 13852)

Tyagi, S.; Ponnampertuma*, C.
A study of peptide synthesis by amino acyl nucleotide anhydrides in presence of complementary homopolynucleotides.
In: *Prebiological Self Organization of Matter* (Ponnampertuma, C., Eirich, F.R., Eds.). Hampton, VA: A. Deepak Publishing, p. 197-210, 1990. (GWU 13836)

Weber*, A.L.; Hsu, V.
Energy-rich glyceric acid oxygen esters: Implications for the origin of glycolysis.
Origins of Life and Evolution of the Biosphere 20: 145-150, 1990. (GWU 12272)

Williams, L.D.; Egli, M.; Gao, Q.; Bash, P.; van der Marel, G.A.; van Boom, J.H.; Rich*, A.; Frederick, C.A.
Structure of nogalamycin bound to a DNA hexamer.
Proceedings of the National Academy of Sciences, USA 87: 2225-2229, 1990. (GWU 13012)

Williams, L.D.; Egli, M.; Ughetto, G.; van der Marel, G.A.; van Boom, J.H.; Quiley, G.J.; Wang, A.H.-J.; Rich*, A.; Frederick, C.A.
Structure of 11-deoxydaunomycin bound to DNA containing a phosphorothioate.
Journal of Molecular Biology 215: 313-320, 1990. (GWU 13014)

Williams, L.D.; Frederick, C.A.; Ughetto, G.; Rich*, A.
Ternary interactions of spermine with DNA: 4'-epiadriamycin and other DNA: Anthracycline complexes.
Nucleic Acids Research 18(18): 5533-5541, 1990. (GWU 13015)

Wittig, B.; Dorbic, T.; Rich*, A.
Measurement of left-handed Z-DNA in permeabilized, metabolically active mammalian nuclei.
In: *DNA Protein Complexes and Proteins* (Sarma, R.H., Sarma, M.H., Eds.). Schenectady, NY: Adenine Press, p. 1-23, 1990. (GWU 14166)

Yuen, G.U.; Pecore, J.A.; Kerridge*, J.F.; Pinnavaia, T.J.; Rightor, E.G.; Flores, J.; Wedeking, K.; Mariner, R.; Des Marais*, D.J.; Chang*, S.
Carbon isotopic fractionation in Fischer-Tropsch Type reactions (Abstract).
Lunar and Planetary Science Conference XXI: 1367-1368, 1990. (GWU 12317)

Yung*, Y.L.
Chemical kinetics and modeling of planetary atmospheres.
In: *First International Conference on Laboratory Research for Planetary Atmospheres* (Fox, K., Allen, J.E., Jr., Stief, L.J., Quillen, D.T., Eds.). Washington, DC: NASA, Headquarters, p. 181-209, 1990. (NASA-CP-3077) (GWU 11713)

Zahnle*, K.; Grinspoon, D.
Comet dust as a source of amino acids at the Cretaceous/Tertiary boundary.
Nature 348(6297): 157-160, 1990. (GWU 13424)

Zahnle*, K.; Kasting*, J.F.; Pollack*, J.B.
Mass fractionation of noble gases in diffusion-limited hydrodynamic hydrogen escape.
Icarus 84: 502-527, 1990. (GWU 12298)

Zahnle*, K.; Pollack*, J.B.; Kasting*, J.F.
Xenon fractionation in porous planetesimals.
Geochimica et Cosmochimica Acta 54: 2577-2586, 1990. (GWU 12276)

Zahnle*, K.J.
Atmospheric chemistry by large impacts.
In: *Global Catastrophes in Earth History: An Interdisciplinary Conference on Impacts, Volcanism, and Mass Mortality* (Sharpton, V.L., Ward, P.D., Eds.). Boulder, CO: Geological Society of America, p. 271-288, 1990. (GSA Special Paper 247) (GWU 13425)

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1

- Beukes, N.J.; Klein, C.; Kaufman, A.J.; Hayes*, J.M.
Carbonate petrography, kerogen distribution, and carbon and oxygen isotope variations in an early Proterozoic transition from limestone to iron-formation deposition, Transvaal Supergroup, South Africa.
Economic Geology and the Bulletin of the Society of Economic Geologists 85(4): 663-690, 1990. (GWU 12565)
- Boreham, C.J.; Fookes, C.J.R.; Popp, B.N.; Hayes*, J.M.
Origin of petroporphyrins. 2. Evidence from stable carbon isotopes.
Energy and Fuels 4(6): 658-661, 1990. (GWU 12566)
- Buchanan*, B.B.; Arnon, D.I.
A reverse Krebs cycle in photosynthesis: Consensus at last.
Photosynthesis Research 24: 47-53, 1990. (GWU 14200)
- Burggraf, S.; Fricke, H.; Neuner, A.; Kristjansson, J.; Rouvier, P.; Mandelco, L.; Woese*, C.R.; Stetter, K.O.
Methanococcus igneus sp. nov., a novel hyperthermophilic methanogen from a shallow submarine hydrothermal system.
Systematic and Applied Microbiology 13(3): 263-269, 1990. (GWU 12603)
- Butterfield, N.J.; Knoll*, A.H.; Swett, K.
A bangiophyte red alga from the Proterozoic of arctic Canada.
Science 250: 104-107, 1990. (GWU 12410)
- Canfield, D.E.; Des Marais*, D.J.
Aerobic sulfate reduction in microbial mats (Abstract).
EOS. Transactions, American Geophysical Union 71(43): 1421, 1990. (GWU 12670)
- Davison, D.B.; Chappellear, J.E. (Fox, G. = P.I.)
The Genbank-Server at the University of Houston.
Nucleic Acids Research 18(6): 1571-1572, 1990. (GWU 12281)
- Des Marais*, D.J.
The carbon isotope biogeochemistry of stromatolites and microbial mats and long-term change of the carbon cycle (Abstract).
In: *1990 V.M. Goldschmidt Conference, Program and Abstracts*, Baltimore, MD, 1990, p. 40.
- Des Marais*, D.J.
Microbial mats and the early evolution of life.
Trends in Ecology and Evolution 5(5): 140-144, 1990. (GWU 11422)
- Des Marais*, D.J.; Southgate, P.N.
Stable isotopic composition of carbonates from the Upper Proterozoic Bitter Springs Formation, Australia (Abstract).
In: *Geological Society of America, Abstracts with Program, 1990 Annual Meeting* 22: A190, 1990.
- Devereux, R.; Loeblich, A.R., III; Fox*, G.E.
Higher plant origins and the phylogeny of green algae.
Journal of Molecular Evolution 31: 18-24, 1990. (GWU 12295)

- Francois, L.M.; Walker*, J.C.G.; Kuhn, W.R.
A numerical simulation of climate changes during the obliquity cycle on Mars.
Journal of Geophysical Research 95(B9): 14761-14778, 1990. (GWU 12497)
- Freeman, K.H.; Hayes*, J.M.; Trendel, J.-M.; Albrecht, P.
Evidence from carbon isotope measurements for diverse origins of sedimentary hydrocarbons.
Nature 343(6255): 254-256, 1990. (GWU 12569)
- Friedmann*, E.I.
Search for traces of endolithic organisms (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 225. (GWU 13622)
- Friedmann*, E.I.; Ocampo-Friedmann, R.
Active life in extreme environments (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 248. (GWU 13621)
- Gelwicks, J.T.; Hayes*, J.M.
Carbon-isotopic analysis of dissolved acetate.
Analytical Chemistry 62: 535-539, 1990. (GWU 12568)
- Grant, S.W.F. (Knoll, A.H. = P.I.)
Shell structure and distribution of *Cloudina*, a potential index fossil for the terminal Proterozoic.
American Journal of Science 290-A: 261-294, 1990. (GWU 12570)
- Gutell, R.R.; Woese*, C.R.
Higher order structural elements in ribosomal RNAs: Pseudo-knots and the use of noncanonical pairs.
Proceedings of the National Academy of Sciences, USA 87: 663-667, 1990. (GWU 12562)
- Hartman, H.; Syvanen, M.; Buchanan*, B.B.
Contrasting evolutionary histories of chloroplast thioredoxins *f* and *m*.
Molecular Biology and Evolution 7(3): 247-254, 1990. (GWU 12601)
- Hayes*, J.M.; Freeman, K.H.
Complete organic-chemical analyses (isotopic as well as structural) reveal molecular histories (Abstract).
Abstracts of Papers of American Chemical Society 200: 37-ANYL, 1990. (GWU 12605)
- Hayes*, J.M.; Freeman, K.H.; Popp, B.N.; Hoham, C.H.
Compound-specific isotopic analyses: A novel tool for reconstruction of ancient biogeochemical processes.
Organic Geochemistry 16(4-6): 1115-1128, 1990. (GWU 12567)
- Hinkle, G.; Margulis*, L.
Global ecology and the Gaia hypothesis.
In: *Physiology and Ecology of Japan* 27(Special Number): 53-62, 1990. (GWU 12624)
- Huppe, H.C.; de Lamotte-Guéry, F.; Jacquot, J.-P.; Buchanan*, B.B.
The ferredoxin-thioredoxin system of a green alga, *Chlamydomonas reinhardtii*.
Planta 180: 341-351, 1990. (GWU 12592)

- Jahnke*, L.L.
Lipid characterization of outer and inner membranes from *Methylococcus capsulatus* (Abstract).
In: *Abstracts of the 90th Annual Meeting of the American Society for Microbiology*, Anaheim, CA, May 13-17, 1990.
- Jasper, J.P.; Hayes*, J.M.
A carbon isotope record of CO₂ levels during the late Quaternary.
Nature 347(6292): 462-464, 1990. (GWU 14201)
- Jorgensen, B.B.; Des Marais*, D.J.
The diffusive boundary layer of sediments: Oxygen microgradients over a microbial mat.
Limnology and Oceanography 35(6): 1343-1355, 1990. (GWU 13426)
- Jukes*, T.H.
Genetic code 1990. Outlook.
Experientia 46(11-12): 1149-1157, 1990. (GWU 14159)
- Jukes*, T.H.
Tectonic drift and evolution.
Journal of Molecular Evolution 31(6): 443-444, 1990. (GWU 14203)
- Jukes*, T.H.; Osawa, S.
The genetic code in mitochondria and chloroplasts.
Experientia 46(11-12): 1117-1126, 1990. (GWU 14165)
- Kasting*, J.F.
Bolide impacts and the oxidation state of carbon in the Earth's early atmosphere.
Origins of Life and Evolution of the Biosphere 20: 199-231, 1990. (GWU 12297)
- Kasting*, J.F.
Earth, the living planet: How life regulates the atmosphere.
Planetary Report X(1): 8-9, 24, 1990. (GWU 12313)
- Kasting*, J.F.
Impacts and the origin of life.
Earth and Mineral Sciences 59(4): 37-42, 1990. (GWU 12277)
- Kaufman, A.J.; Hayes*, J.M.; Klein, C.
Primary and diagenetic controls of isotopic compositions of iron-formation carbonates.
Geochimica et Cosmochimica Acta 54(12): 3461-3473, 1990. (GWU 12564)
- Knoll*, A.H.
Precambrian evolution of prokaryotes and protists.
In: *Palaeobiology: A Synthesis* (Briggs, D.E.G., Crowther, P.R., Eds.). Oxford, England: Blackwell Scientific Publications, p. 9-16, 1990. (GWU 12573)
- Knoll*, A.H.; Swett, K.
Carbonate deposition during the late Proterozoic era: An example from Spitsbergen.
American Journal of Science 290-A: 104-132, 1990. (GWU 12571)

Kretsinger*, R.H.; Moncrief, N.D.; Persechini, A.
The central helix of calmodulin and homologs: Effects of solvent exposure on stability.
In: *Water and Ions in Biomolecular Systems: Advances in Life Sciences* (Vasilescu, D., Jaz, J., Packer, L., Pullmann, B., Eds.). Basel, Switzerland: Birkhäuser Verlag, p. 93-100, 1990. (GWU 12660)

Lanyi*, J.K.; Duschl, A.; Hatfield, G.W.; May, K.; Oesterhelt, D.
The primary structure of a halorhodopsin from *Natronobacterium pharaonis*.
Journal of Biological Chemistry 265(3): 1253-1260, 1990. (GWU 12591)

Lanyi*, J.K.; Duschl, A.; Váro, G.; Zimányi, L.
Anion binding to the chloride pump, halorhodopsin, and its implications for the transport mechanism.
FEBS Letters 265(1, 2): 1-6, 1990. (GWU 12597)

Lowe*, D.R.
Paleoecology of early microbial communities (Abstract).
In: *Abstracts, 156th Annual Meeting of the American Association for the Advancement of Science*, 1990, p. 19. (GWU 7272)

Maliva, R.G.; Knoll*, A.H.; Siever, R.
Secular change in chert distribution: A reflection of evolving biological participation in the silica cycle.
Palaos 4: 519-532, 1990. (GWU 12572)

Margulis*, L.
Des procaryotes aux protistes eucaryotes. (French)
In: *Journée Edouard Chatton, 17 Juin 1988, "Conférences."* Mémoires du Muséum d'Histoire Naturelle de Perpignan, France, p. 14-16, 1990. (GWU 12626)

Margulis*, L.
Kingdom Animalia: The zoological malaise from a microbial perspective.
American Zoologist 30: 861-875, 1990. (GWU 10099)

Margulis*, L.
Speculation on speculation.
In: *The Reality Club: Speculation* (Brockman, J., Ed.). New York: Prentice Hall Press, p. 158-167, 1990. (GWU 12622)

Margulis*, L.
Words as battle cries - symbiogenesis and the new field of endocytobiology.
BioScience 40(9): 673-677, 1990. (GWU 12616)

Margulis*, L.; Corliss, J.O.; Melkonian, M.; Chapman, D.J. (Eds.)
Handbook of Protoctista: The structure, cultivation, habitats and life histories of the eukaryotic microorganisms and their descendants exclusive of animals, plants and fungi.
Boston, MA: Jones and Bartlett Publishers, 1990. (GWU 12627)

Margulis*, L.; Enzien, M.; McKhann, H.I.
Revival of Dobell's "Chromidia" hypothesis: Chromatin bodies in the amoebomastigote *Paratetramitus jugosus*.
Biological Bulletin 178: 300-304, 1990. (GWU 12614)

- Margulis*, L.; Guerrero, R.
From origins of life to evolution of microbial communities: A minimalist approach.
In: *Prebiological Self Organization of Matter* (Ponnamperuma, C., Eirich, F.R., Eds.). Hampton, VA: A. Deepak Publishing, p. 261-278, 1990. (GWU 12621)
- Margulis*, L.; Hinkle, G.; Stolz, J.; Craft, F.; Esteve, I.; Guerrero, R.
Mobilifilum chasei: Morphology and ecology of a spirochete from an intertidal stratified microbial mat community.
Archives of Microbiology 153: 422-427, 1990. (GWU 12613)
- Margulis*, L.; Hinkle, G.; Tzertzinis, G.
Symbiosis in the origin of eukaryotic cell motility: Current status.
In: *Endocytobiology IV* (Nardon, P., Gianinazzi-Pearson, V., Grenier, A.M., Margulis, L., Smith, D.C., Eds.). Paris, France: INRA, p. 523-525, 1990. (GWU 12667)
- Margulis*, L.; McMenamin, M.
Kinetosome-centriolar DNA: Significance for endosymbiosis theory.
Treballs de la Societat Catalana de Biologia 40: 191-197, 1990. (GWU 12666)
- Margulis*, L.; McMenamin, M.
Marriage of convenience: The motility of the modern cell may reflect an ancient symbiotic union.
The Sciences 30(5): 30-37, 1990. (GWU 12612)
- Margulis*, L.; Olendzenski, L.; Afzelius, B.A.
Endospore-forming filamentous bacteria symbiotic in termites: Ultrastructure and growth in culture of *Arthromitus*.
Symbiosis 8: 95-116, 1990. (GWU 6609)
- Margulis*, L.; Sagan, D.
Water and Gaia.
Annals of Earth 8(3): 24-25, 1990. (GWU 12625)
- Moncrief, N.D.; Kretsinger*, R.H.; Goodman, M.
Evolution of EF-hand calcium-modulated proteins. I. Relationships based on amino acid sequences.
Journal of Molecular Evolution 30: 522-562, 1990. (GWU 12590)
- Nardon, P.; Gianinazzi-Pearson, V.; Grenier, A.M.; Margulis*, L.; Smith, D.C. (Eds.)
Endocytobiology IV. Paris, France: INRA, 620 p., 1990. (GWU 13870)
- Ohama, T.; Osawa, S.; Watanabe, K.; Jukes*, T.H.
Evolution of the mitochondrial genetic code IV. AAA as an asparagine codon in some animal mitochondria.
Journal of Molecular Evolution 30: 329-332, 1990. (GWU 11491)
- Oren, A.; Ginzburg, M.; Ginzburg, B.Z.; Hochstein*, L.I.; Volcani, B.E.
Haloarcula marismortui (Volcani) sp. nov., nom. rev., an extremely halophilic bacterium from the Dead Sea.
International Journal of Systematic Bacteriology 40(2): 209-210, 1990. (GWU 14202)

- Osawa, S.; Collins, D.; Ohama, T.; Jukes*, T.H.; Watanabe, K.
Evolution of the mitochondrial genetic code III. Reassignment of CUN codons from leucine to threonine during evolution of yeast mitochondria.
Journal of Molecular Evolution 30: 322-328, 1990. (GWU 11490)
- Osawa, S.; Muto, A.; Jukes*, T.H.; Ohama, T.
Evolutionary changes in the genetic code.
Proceedings of the Royal Society of London Series B: Biological Sciences 241: 19-28, 1990. (GWU 14204)
- Palmer, R.J., Jr.; Friedmann*, E.I.
Water relations and photosynthesis in the cryptoendolithic microbial habitat of hot and cold deserts.
Microbial Ecology 19: 111-118, 1990. (GWU 13419)
- Palmer, R.J., Jr.; Friedmann*, E.I.
Water relations, thallus structure and photosynthesis in Negev Desert lichens.
New Phytologist 116: 597-603, 1990. (GWU 13418)
- Rau, G.H. (Des Marais, D.J. = P.I.)
AMERIEZ 1986: Carbon-13 and nitrogen-15 natural abundances in southern ocean biota collected during AMERIEZ 1986.
Antarctic Journal of the U.S. 24: 168-169, 1990. (GWU 14088)
- Rau, G.H.; Takahashi, T.; Des Marais*, D.J.
The relationship between marine plankton $\delta^{13}\text{C}$ and $[\text{CO}_2(\text{aq})]$: Paleoceanographic implications (Abstract).
In: *1990 V.M. Goldschmidt Conference, Program and Abstracts*, Baltimore, MD, 1990, p. 76.
- Rau, G.H.; Takahashi, T.; Des Marais*, D.J.; Repeta, D.; Martin, J.
POM $\delta^{13}\text{C}$ is negatively correlated with $[\text{CO}_2(\text{aq})]$ at the JGOFS N. Atlantic Site (Abstract).
EOS. Transactions, American Geophysical Union 71(43): 1417, 1990. (GWU 8925)
- Rothschild, L.J.; Mancinelli*, R.L.
Model of carbon fixation in microbial mats from 3,500 Myr ago to the present.
Nature 345(6277): 710-712, 1990. (GWU 14025)
- Schopf*, J.W.
Evolution of early life microfossils and stromatolites (Abstract).
In: *Fourth International Congress of Systematic and Evolutionary Biology*, College Park, MD, July 1-7, 1990, p. 64.
- Steinberg, N.C.; Culbertson, C.; Blunden, P.; Pasilis, R.S.; Oremland, R.S.; Hochstein*, L.
Bacterial dissimilatory selenate and selenite by denitrifying isolates (Abstract).
In: *Abstracts of the 90th Annual Meeting of the American Society for Microbiology*, Anaheim, CA, May 13-17, 1990.
- Summons, R.E.; Jahnke*, L.L.
Identification of the methylhopanes in sediments and petroleum.
Geochimica et Cosmochimica Acta 54: 247-251, 1990. (GWU 14092)

Sun, H.J.; Friedmann*, E.I.

Long term (10^3 - 10^4 y) growth dynamics of the Antarctic cryptoendolithic microbial community (Abstract).

In: *Abstracts of the 90th Annual Meeting of the American Society for Microbiology*, Anaheim, CA, May 13-17, 1990, p. 202. (GWU 13615)

Toulkeridis, T.; Goldstein, S.L.; Kröner, A.; Lowe*, D.R.; Schidlowski, M.

Late Archaean Rb-Sr, Pb-Pb, and Sm-Nd resetting of early Archaean Barberton Greenstone Belt carbonates (Abstract).

In: *Third International Archaean Symposium, Extended Abstracts* (Glover, J.E., Ho, S.E., Compilers). Perth, Scotland: Geoconferences (W.A.) Inc., p. 309-310, 1990. (GWU 6533)

Toulkeridis, T.; Todt, W.; Kröner, A.; Lowe*, D.R.

Pb-Pb dating of a carbonate rock from the Onverwacht Group, Barberton Greenstone Belt, South Africa (Abstract).

Abstracts, Congress on African Geology, Nancy, France, 1990, 1 p. (GWU 7241)

Trost, J.T.; Blankenship*, R.E.

Isolation of a reaction center particle and a small *c*-type cytochrome from *Heliobacillus mobilis*.

In: *Current Research in Photosynthesis, Volume II* (Baltscheffsky, M., Ed.). Dordrecht, Holland: Kluwer Academic Publishers, p. 703-706, 1990. (GWU 6662)

Walker*, J.C.G.

Origin of an inhabited planet.

In: *Origin of the Earth* (Newsom, H.E., Jones, J.H., Eds.). New York: Oxford University Press, p. 371-375, 1990. (GWU 12557)

Walker*, J.C.G.

Precambrian evolution of the climate system.

Palaeogeography, Palaeoclimatology, Palaeoecology 82(3-4): 261-289, 1990. (GWU 12500)

Ward, D.M.; Weller, R.; Bateson, M.M. (Woese, C.R. = P.I.)

16S rRNA sequences reveal numerous uncultured microorganisms in a natural community.

Nature 344(6270): 63-65, 1990. (GWU 13839)

Ward, D.M.; Weller, R.; Bateson, M.M. (Woese, C.R. = P.I.)

16S rRNA sequences reveal uncultured inhabitants of a well-studied thermal community.

FEMS Microbiology Reviews 75: 105-116, 1990. (GWU 13840)

Winker, S.; Oberbeek, R.; Woese*, C.R.; Olsen, G.J.; Pflüger, N.

Structure detection through automated covariance search.

Computer Applications in the Biosciences 6(4): 365-371, 1990. (GWU 14205)

Wisotzkey, J.D.; Jurtshuk, P., Jr.; Fox*, G.E.

PCR amplification of 16S rDNA from lyophilized cell cultures facilitates studies in molecular systematics.

Current Microbiology 21: 325-327, 1990. (GWU 12294)

Woese*, C.R.; Kandler, O.; Wheelis, M.L.

Towards a natural system of organisms: Proposal for the domains Archaea, Bacteria, and Eucarya.

Proceedings of the National Academy of Sciences, USA 87: 4576-4579, 1990. (GWU 12563)

Woese*, C.R.; Mandelco, L.; Yang, D.; Gherna, R.; Madigan, M.T.
The case for relationship of the flavobacteria and their relatives to the green sulfur bacteria.
Systematic and Applied Microbiology 13(3): 258-262, 1990. (GWU 12602)

Woese*, C.R.; Wächtershäuser, G.
Origin of life.

In: *Palaeobiology: A Synthesis* (Briggs, D.E.G., Crowther, P.R., Eds.). Oxford, England:
Blackwell Scientific Publications, p. 3-9, 1990. (GWU 9849)

Woese*, C.R.; Winker, S.; Gutell, R.R.
Architecture of ribosomal RNA: Constraints on the sequence of "tetra-loops."
Proceedings of the National Academy of Sciences, USA 87: 8467-8471, 1990. (GWU 12561)

Evolution of Advanced Life

Alvarez, W.; Asaro*, F.
An extraterrestrial impact.
Scientific American 263: 78-84, 1990. (GWU 14206)

Alvarez, W.; Asaro*, F.; Montanari, A.
Iridium profile for 10 million years across the Cretaceous-Tertiary boundary at Gubbio (Italy).
Science 250(4988): 1700-1702, 1990. (GWU 14207)

Briggs*, J.C.
Global extinctions, recoveries and evolutionary consequences.
Evolutionary Monographs 13: 47 p., 1990. (GWU 12271)

Caldeira, K.; Rampino*, M.R.
Carbon dioxide emissions from Deccan volcanism and a K/T boundary greenhouse effect.
Geophysical Research Letters 17(9): 1299-1302, 1990. (GWU 12581)

Caldeira, K.; Rampino*, M.R.
Carbonate-silicate cycle modeling at the Cretaceous/Tertiary boundary (Abstract).
In: *Abstracts, Cretaceous Rhythms, Events and Resources*, Denver, CO, August 20-24, 1990, p. 88-89.

Caldeira, K.; Rampino*, M.R.; Volk*, T.; Zachos, J.C.
Biogeochemical modeling at mass extinction boundaries: Atmospheric carbon dioxide and ocean alkalinity at the K/T boundary.
In: *Extinction Events in Earth History* (Kauffman, E.G., Walliser, O.H., Eds.). Berlin: Springer-Verlag, p. 333-345, 1990. (GWU 12421)

Caldeira, K.G.; Rampino*, M.R.
Deccan volcanism, greenhouse warming, and the Cretaceous/Tertiary boundary.
In: *Global Catastrophes in Earth History: An Interdisciplinary Conference on Impacts, Volcanism, and Mass Mortality* (Sharpton, V.L., Ward, P.D., Eds.). Boulder, CO: Geological Society of America, p. 117-123, 1990. (GSA Special Paper 247) (GWU 12589)

Caldeira, K.G.; Rampino*, M.R.
Sensitivity of the carbon geochemical cycle to changes in marine biosphere productivity at the Cretaceous/Tertiary boundary (Abstract).
In: *Geological Society of America, Abstracts with Program, 1990 Annual Meeting* 22: A94, 1990.

Lischner, D.; Rampino*, M.R.; Hoffert, M.I.; Caldeira, K.
Relationships between feedback mechanisms and historical climate variations in a coupled carbon, hydrologic and energy-balance model (Abstract).
EOS. Transactions, American Geophysical Union 71(43): 1252, 1990. (GWU 14022)

Raup*, D.M.
Catastrophes and the history of life on Earth.
In: *The Restless Earth* (Carlson, K.J., Ed.). New York: Harper & Row, p. 163-188, 1990. (GWU 12558)

Raup*, D.M.

Impact as a general cause of extinction; A feasibility test.

In: *Global Catastrophes in Earth History: An Interdisciplinary Conference on Impacts, Volcanism, and Mass Mortality* (Sharpton, V.L., Ward, P.D., Eds.). Boulder, CO: Geological Society of America, p. 27-32, 1990. (GSA Special Paper 247) (GWU 12661)

Raup*, D.M.

Paleontological evidences of great extinctions and cycles (Abstract).

Swiss Academy of Sciences Annual Meeting, Abstracts with Program, 1990.

Raup*, D.M.

Periodic phenomena in the geological record of mass extinctions (Abstract).

In: *MULTIER Symposium, Abstracts with Program*, University of Tokyo, 1990, p. 29.

Raup*, D.M.

Scaling background and mass extinction (Abstract).

In: *Fourth International Congress of Systematic and Evolutionary Biology*, College Park, MD, July 1-7, 1990, p. 111.

Sepkoski*, J.J., Jr.

Diversity in the marine fossil record (Abstract).

In: *Abstracts, 156th Annual Meeting of the American Association for the Advancement of Science*, 1990, p. 83.

Sepkoski*, J.J., Jr.

Evolutionary faunas.

In: *Palaeobiology: A Synthesis* (Briggs, D.E.G., Crowther, P.R., Eds.). Oxford, England: Blackwell Scientific Publications, p. 37-41, 1990. (GWU 14208)

Sepkoski*, J.J., Jr.

Evolutionary radiations and onshore-offshore diachroneity in faunal change (Abstract).

In: *International Geological Correlation Programme 216 and 303, Global Biological Events, Abstracts*, 1990, p. 2.

Sepkoski*, J.J., Jr.

Overview of Phanerozoic diversity patterns (Abstract).

In: *Fourth International Congress of Systematic and Evolutionary Biology*, College Park, MD, July 1-7, 1990, p. A-199.

Sepkoski*, J.J., Jr.

Periodicity.

In: *Palaeobiology: A Synthesis* (Briggs, D.E.G., Crowther, P.R., Eds.). Oxford, England: Blackwell Scientific Publications, p. 171-179, 1990. (GWU 14209)

Trefil, J.S.; Raup*, D.M.

Crater taphonomy and bombardment rates in the Phanerozoic.

Journal of Geology 98(3): 385-398, 1990. (GWU 12496)

Solar System Exploration

Andersen, D.T.; McKay*, C.P.; Wharton*, R.A., Jr.; Rummel*, J.D.
An Antarctic research outpost as a model for planetary exploration.
Journal of the British Interplanetary Society 43: 499-504, 1990. (GWU 12413)

Andersen, D.T.; Wharton*, R.A.; McKay*, C.P.; Rummel*, J.D.
An Antarctic research outpost as a model for planetary exploration (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 228. (GWU 14210)

Bishop, J.; Wharton*, R.A., Jr.; Koeberl, C.; McKay*, C.P.; Foster, L.A.; Englert, P.A.J.
Terrestrial analog studies of early Martian environments: Chemical analysis of sediments from Lake Hoare, Antarctica (Abstract).
Lunar and Planetary Science Conference XXI: 91-92, 1990. (GWU 13584)

Carle*, G.; Mancinelli*, R.; Wharton*, R.
The analysis of Martian soil volatiles using a thermal processor/evolved gas analyzer.
In: *Exobiology on Mars* (DeVincenzi, D.L., Marshall, J.R., Andersen, D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 15-17, 1990. (NASA-CP-10055) (GWU 14097)

Clark, B.; Chang*, S.; Oro*, J.
Specific-electrode measurement of chemical properties of the Martian soil.
In: *Exobiology on Mars* (DeVincenzi, D.L., Marshall, J.R., Andersen, D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 7-9, 1990. (NASA-CP-10055) (GWU 14095)

Davis, W.L.; McKay*, C.P.
Liquid water habitats on early Mars (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 249. (GWU 14211)

DeBergh, C.; Bezard, B.; Crisp, D.; Maillard, J.-P.; Owen*, T.; Lutz, B.
Measurement of the D/H ratio in the deep atmosphere of Venus from ground-based spectroscopy of the night side (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 130. (GWU 14212)

DeVincenzi*, D.L.; Marshall, J.R.; Andersen, D. (Eds.)
Exobiology on Mars. Moffett Field, CA: NASA, Ames Research Center, 42 p., 1990.
(NASA-CP-10055) (GWU 14102)

Esposito, L.W.; Pepin, R.O.; Cheng, A.F.; Jakosky, B.M.; Lunine, J.I.; McFadden, L.-A.; McKay*, C.P.; McKinnon, W.B.; Muhleman, D.O.; Nicholson, P.; Pace, N.R.; Schubert, G.; Schultz, P.H.; Spudis, P.D.; Stone, P.H.; Taylor, G.J.; Zurek, R.W.
1990 Update to Strategy for Exploration of the Inner Planets. Washington, DC: National Academy Press, 53 p., 1990. (NASA CR-188728) (GWU 14213)

Fogleman*, G.C.; Huntington, J.L.; Stratton, D.M.; Coulter, G.
Simulation of cosmic dust formation and interaction using the Gas-Grain Simulation Facility in low Earth orbit (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 110-111. (GWU 14214)

- Friedmann*, E.I.; Schwartz-Kolyer, D.
Biological pattern recognition in Mars imaging.
In: *Exobiology on Mars* (DeVincenzi, D.L., Marshall, J.R., Andersen, D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 23-24, 1990. (NASA-CP-10055) (GWU 14099)
- Gooding, J.L. (McKay, C.P. = P.I.)
Scientific Guidelines for Preservation of Samples Collected from Mars. Houston, TX: NASA, Johnson Space Center, 242 p., 1990. (NASA-TM-4184) (GWU 12486)
- Hall, K.W.; Valentin*, J.R.; Phillips, J.B.
Development of a modulator to measure water vapor selectively in a gaseous mixture.
Journal of High Resolution Chromatography 13: 835-837, 1990. (GWU 14085)
- Haynes, R.H.; McKay*, C.P.
Ecopoiesis, prospects for establishing a microbial ecosystem on Mars (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 226. (GWU 14215)
- Hourdin, F.; Levan, P.; Talagrand, O.; Courtin, R.; Gautier, D.; McKay*, C.P.
The circulation of the atmosphere of Titan: Development of a general circulation model (Abstract).
Bulletin of the American Astronautical Society 22(3): 1086, 1990. (GWU 14216)
- Huebner, W.F.; McKay*, C.P.
Implications of comet research.
In: *Physics and Chemistry of Comets* (Huebner, W.F., Ed.). Berlin: Springer-Verlag, p. 305-331, 1990. (GWU 13638)
- Huntington, J.L.; Tsou*, P.; Fogleman*, G.C.; Carle*, G.C.
Passive and active cosmic dust collection techniques for "in situ" capture in Earth orbit (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 110. (GWU 14217)
- Lellouch, E.; Belton, M.; DePater, I.; Gulkis*, S.; Encrenaz, T.
Io's atmosphere from microwave detection of SO₂ (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 29. (GWU 14218)
- Lumme, K.; Peltoniemi, J.; Irvine*, W.M.
Some photometric techniques for atmosphereless solar system bodies.
Advances in Space Research 10(1): 187-193, 1990. (GWU 12279)
- Mancinelli*, R.L.; White, M.R.; Marshall, J.R.
Analyses of exobiological and potential resource materials in the Martian soil (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 225. (GWU 14219)
- McKay*, C.
The detection of anaerobic chemoautotrophs on Mars.
In: *Exobiology on Mars* (DeVincenzi, D.L., Marshall, J.R., Andersen, D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 27-28, 1990. (NASA-CP-10055) (GWU 14101)

McKay*, C.P.

Does Mars have rights? An approach to the environmental ethics of planetary engineering.

In: *Moral Expertise* (MacNiven, D., Ed.). London: Routledge, p. 184-197, 1990.

(GWU 13578)

McKay*, C.P.

History of water on Mars (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague,

The Netherlands, June 25-July 6, 1990, p. 248. (GWU 14220)

McKay*, C.P.

La vie sur Mars. (French)

La Recherche 21(225): 1216-1224, 1990. (GWU 13580)

McKay*, C.P.; Haynes, R.H.

Should we implant life on Mars?

Scientific American 263(6): 144, 1990. (GWU 13579)

McKay*, C.P.; Pollack*, J.B.; Lunine, J.I.; Courtin, R.

Coupled atmosphere-ocean models of Titan's past (Abstract).

Bulletin of the American Astronautical Society 22(3): 1086, 1990. (GWU 14221)

McKay*, C.P.; Stoker, C.R.

Could the early environment of Mars have supported the development of life?

Earth in Space 2: 10-12, 1990.

Muinonen, K.; Lumme, K.; Peltoniemi, J.; Irvine*, W.M.

Statistical photoclinometry and surface topography of atmosphereless bodies.

In: *Asteroids, Comets, Meteors III* (Lagerkvist, C.I., Ed.). Uppsala University, p. 155, 1990.

Muinonen, K.; Lumme, K.; Zhukov, B.; Peltoniemi, J.I.; Kaasalainen, M.; Irvine*, W.M.

Statistical Photoclinometric Methods for the Analysis of Surface Topography.

Moscow: Space Research Institute, USSR Academy of Sciences, 16 p., 1990. (Publication

Pr-1631) (GWU 14222)

Nier, A.; Oro*, J.; Des Marais*, D.; Rushneck, D.

The detection of organics and volatiles with mass spectrometry.

In: *Exobiology on Mars* (DeVincenzi, D.L., Marshall, J.R., Andersen, D., Eds.). Moffett Field,

CA: NASA, Ames Research Center, p. 19-21, 1990. (NASA-CP-10055) (GWU 14098)

Oberbeck*, V.R.; Marshall, J.R.; Schwartz, D.E.

A model for chemical evolution of life on Mars (Abstract).

Lunar and Planetary Science Conference XXI: 905-906, 1990. (GWU 13618)

Oberbeck*, V.R.; Marshall, J.R.; Schwartz, D.E.; Mancinelli*, R.L.

Search for life: A science rationale for a permanent base on Mars (Abstract).

Lunar and Planetary Science Conference XXI: 907-908, 1990. (GWU 13617)

Owen*, T.

Evolution of the Martian atmosphere (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague,

The Netherlands, June 25-July 6, 1990, p. 17. (GWU 14223)

Owen*, T.; Lutz, B.L.; DeBergh, C.; Maillard, J.P.
Composition of Neptune and Triton atmospheres (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 21-22. (GWU 14224)

Pollack*, J.B.
Voyager imaging observations of clouds and hazes in Neptune's atmosphere (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 22. (GWU 14227)

Rothschild, L.J. (Mancinelli, R.L. = P.I.)
Earth analogs for Martian life, microbes in evaporites, a new model system for life on Mars.
Icarus 88: 246-260, 1990. (GWU 14089)

Roush*, T.; Pollack*, J.; Orenberg*, J.
Derivation of mid-infrared (5-25 μm) optical constants of some silicates and palagonite (Abstract).
Lunar and Planetary Science Conference XXI: 1043-1044, 1990. (GWU 14090)

Rvanesov, G.; Bonev, B.; Boycheva, V.; Danz, M.; Duxbury, T.; Fanale, F.; Halmann, D.; Head, J.; Hezkenhoff, K.; Kempe, F.; Kostenko, V.; Kzumov, A.; Kuzminz, A.; Irvine*, W.; Lumme, K.; Mishev, D.; Muinonen, K.; Muzavev, V.; Muzchie, S.; Muzzay, B.; Neumann, W.; Paul, L.; Peltoniemi, J.; Petkov, D.; Petuchova, I.; Posel, W.; Rebel, B.; Shkuzatov, Y.; Simeonov, S.; Smith, B.; Uzunov, Y.; Fedotov, V.; Weide, G.G.; Zhukov, B.; Zima, Y.
TV imaging of Phobos (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 19. (GWU 14225)

Schwartz, D.E.; Mancinelli*, R.L.
Using mineral crystals as biomarkers in the search for life on Mars (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 225. (GWU 14226)

Stoker, C.; Seiff, A.; Klein*, H.P.; McKay*, C.; Day, R.
Survey of oxidants in the Mars near-surface layer.
In: *Exobiology on Mars* (DeVincenzi, D.L., Marshall, J.R., Andersen, D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 11-14, 1990. (NASA-CP-10055) (GWU 14096)

Stoker, C.R.; McKay*, C.P.
The case for human exploration of Mars.
Paper presented at AIAA Space Programs and Technologies Conference, Huntsville, AL, September 25-28, 1990, 8 p. (AIAA-90-3792) (GWU 13626)

Stoker, C.R.; Rages, K.; Pollack*, J.B.
Methane convection on Neptune: Evidence from the Voyager imaging experiment (Abstract).
In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 22-23. (GWU 14228)

Thompson, W.R.; Sagan*, C.
Color and chemistry on Triton.
Science 250: 415-418, 1990. (GWU 12412)

Tsou*, P.

Intact capture of hypervelocity projectiles.

International Journal of Impact Engineering 10: 615-627, 1990. (GWU 12282)

Tsou*, P.; Bradley, J.P.; Brownlee, D.E.; Fechtig, H.; Hrubesh, F.L.; Keaton, P.W.; Lurance, M.; Simon, C.G.; Stradling, G.L.; Teetsov, A.; Albee, A.L.

Intact capture of cosmic dust analogs in aerogel (Abstract).

Lunar and Planetary Science Conference XXI: 1264-1265, 1990. (GWU 12499)

Valentin*, J.R.; Hall, K.W.; Becker, J.F.

Continuous monitoring of a changing sample by multiplex gas chromatography.

Journal of Chromatography 518: 199-206, 1990. (GWU 14093)

Webster, C.; Owen*, T.; Hunten, D.

Infrared laser spectrometer for *in situ* sensing of the Martian atmosphere.

In: *Exobiology on Mars* (DeVincenzi, D.L., Marshall, J.R., Andersen, D., Eds.). Moffett Field, CA: NASA, Ames Research Center, p. 25-26, 1990. (NASA-CP-10055) (GWU 14100)

Wharton*, R.A.; McKay*, C.P.

Life on ice (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 249. (GWU 14229)

Yung*, Y.L.; Lyons, J.R.

Triton: Topside ionosphere and nitrogen escape.

Geophysical Research Letters 17(10): 1717-1720, 1990. (GWU 14230)

Search for Extraterrestrial Intelligence (SETI)

45

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Betz*, A.L.; Boreiko, R.T.
Far-infrared heterodyne technology.
In: *From Ground-Based to Space-Borne Sub-mm Astronomy* (Kaldeich, B., Ed.). Noordwijk, The Netherlands: European Space Agency, p. 205-210, 1990. (ESA SP-314) (GWU 14231)

Billingham*, J.
Risk and value analysis of SETI.
Acta Astronautica 21(2): 69-72, 1990. (GWU 12607)

Billingham*, J.; Michaud, M.; Tarter*, J.
The declaration of principles for activities following the detection of extraterrestrial intelligence.
Paper presented at the Third Bioastronomy Symposium, Val Cenis, France, June 18-23, 1990, 6 p. (GWU 12618)

Bowyer*, S.
The U.C. Berkeley Program.
In: *First Contact: The Search for Extraterrestrial Intelligence* (Bova, B., Preiss, B., Eds.). New York: Bryon Preiss Visual Publications, p. 215-220, 1990. (GWU 12560)

Cullers*, D.K.
SETI project to build largest search system.
On Line 12(12): 1-3, 1990. (GWU 9701)

Cullers*, D.K.; Alschuler, W.R.
Individual involvement.
In: *First Contact: The Search for Extraterrestrial Intelligence* (Bova, B., Preiss, B., Eds.). New York: Bryon Preiss Visual Publications, p. 281-301, 1990. (GWU 13789)

Dixon*, R.S.
The Ohio State University Program.
In: *First Contact: The Search for Extraterrestrial Intelligence* (Bova, B., Preiss, B., Eds.). New York: Bryon Preiss Visual Publications, p. 199-205, 1990. (GWU 13787)

Donnelly, C.; Bowyer*, S.; Herrick, W.; Werthimer, D.; Lampton, M.; Hiatt, T.
The SERENDIP II SETI Project: Observations and RFI Analysis.
Paper presented at the Third Bioastronomy Symposium, Val Cenis, France, June 18-23, 1990, 4 p. (GWU 12559)

Drake*, F.D.
Reflections on the modern history of SETI.
Paper presented at the 41st Congress of the International Astronautical Federation, Dresden, Germany, October 6-12, 1990, 2 p. (IAA-90-574) (GWU 12636)

Duluk, J.F., Jr.; Jeday, A.; Massing, M.; Chen, C.-K.; Nguyen, H.
The MCSA 2.1: A fully digital real-time spectrum analyzer developed for NASA's SETI project.
Paper presented at the 41st Congress of the International Astronautical Federation, Dresden, Germany, October 6-12, 1990, 7 p. (IAA-90-577) (GWU 12635)

Gulkis*, S.; Biraud, F.; Heidmann, J.; Tarter*, J.C.
Technical considerations on using the large Nancay Radio Telescope for SETI.
In: *TDA Progress Report 42-102*. Pasadena, CA: Jet Propulsion Laboratory, April-June 1990, p. 152-160. (GWU 12631)

Klein*, M.J.

Where and what can we see?

In: *First Contact: The Search for Extraterrestrial Intelligence* (Bova, B., Preiss, B., Eds.).
New York: Bryon Preiss Visual Publications, p. 143-158, 1990. (GWU 13786)

Klein*, M.J.; Gulkis*, S.

The impact of technology on SETI.

Paper presented at the Third International Bioastronomy Symposium, Val Cenis, France, June 18-23, 1990, 7 p. (GWU 12576)

Klein*, M.J.; Gulkis*, S.; Wilck, H.C.

SETI prototype system for NASA's Sky Survey Microwave Observing Project: A progress report.

Paper presented at the 41st Congress of the International Astronautical Federation, Dresden, Germany, October 6-12, 1990, 7 p. (IAA-90-576) (GWU 12575)

Michaud, M.; Billingham*, J.; Tarter*, J.

A reply from Earth? A proposed approach to developing a message from humankind to extraterrestrial intelligence after we detect them.

Paper presented at the 41st Congress of the International Astronautical Federation, Dresden, Germany, October 6-12, 1990, 2 p. (IAA-90-591) (GWU 12633)

Oliver*, B.M.

A review of interstellar rocketry fundamentals.

Journal of the British Interplanetary Society 43: 259-264, 1990. (GWU 11721)

Olsen, E.T.; Jackson, E.B.; Gulkis*, S.

RFI site surveys in the band 1.0 GHz -> 10.4 GHz (Abstract).

In: *Proceedings of the URSI National Radio Science Meeting*, Boulder, CO, January 3-5, 1990, p. 236. (GWU 12577)

Olsen, E.T.; Jackson, E.B.; Gulkis*, S.

RFI surveys of selected radio observatories.

Paper presented at the Third International Bioastronomy Symposium, Val Cenis, France, June 18-23, 1990, 7 p. (GWU 12578)

Shostak*, S.

Is anybody listening?

Pacific Discovery 43(4): 40-45, 1990. (GWU 12634)

Tarter*, J.; Klein*, M.

SETI: On the telescope and on the drawing board.

Paper presented at the Third Bioastronomy Symposium, Val Cenis, France, June 18-23, 1990, 6 p. (GWU 12632)

Tarter*, J.C.

Summary of interference measurements at selected radio observatories.

Paper presented at the 41st Congress of the International Astronautical Federation, Dresden, Germany, October 6-12, 1990, 5 p. (IAA-90-580) (GWU 12619)

Tarter*, J.C.; Backus*, P.; Cullers*, D.K.; Gulkis*, S.; Olsen, E.T.; Jackson, E.B.; Dreher, J.; Werthimer, D.; Herrick, W.

An attempt to characterize RFI at Arecibo for future SETI observations (Abstract).

In: *Proceedings of the URSI National Radio Science Meeting*, Boulder, CO, January 3-5, 1990, p. 240. (GWU 14175)

Tarter*, J.C.; Michaud, M.A. (Eds.)

SETI Post Detection Protocol.

Acta Astronautica 21(2): 1-80, 1990. (GWU 12628)

Tarter*, J.C.; Rummel*, J.

Exobiology and SETI from the lunar farside.

American Institute of Physics 207: 99-106, 1990. (GWU 12630)



Planetary Protection

Bourke, R.D.; McKay*, C.P.

The Mars Robotic Precursor Programme and planetary protection strategy (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 226. (GWU 14232)

DeVincenzi*, D.L.

Planetary protection issues and the Human Exploration Initiative (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 226. (GWU 14233)

Rummel*, J.D.

Planetary Protection Policy (USA) (Abstract).

In: *Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research*, The Hague, The Netherlands, June 25-July 6, 1990, p. 226. (GWU 14234)

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